Research Priorities for Fiscal Years 2021-2023

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Executive Summary:

Things look very different than they did at the start of BPA's Technology Innovation (TI) program in 2005. Notably, there are fewer resources, both financial and personnel, resulting in a smaller portfolio, and a reimagined framework to manage research activities. However, there is still a need to articulate what research is important to BPA given these constraints. These guidelines help to manage conversations and expectations around research efforts - it is a fundamental requirement of the program going forward.

Research Priorities are expressions of need over the next 2-3 years by key stakeholders related to innovation within BPA. Since Technology Innovation shifted to a more nimble project selection approach, the TI Team finds that ***Research Priorities*** remain an important tool to guide the scope of proposals that warrant meaningful consideration as RD&D Projects. TI uses Research Priorities and Research Principles to ensure direct value to the Agency before developing project proposals for consideration by Agency Leadership. See the TI Project Funnel to understand how these two elements of a Research Agenda work together to refine RD&D project scope and deliver greater value to the Agency.

TI's Research Priorities began as a list of risk and opportunities developed through interviews with Internal Stakeholders in the Fall of 2020. TI then added topics from current projects, discussions with internal specialists in Enterprise Risk and IT and topics developed by industry associations leading innovation for wholesale energy generation and distribution. Before finalizing the list, TI asked the interviewees to prioritize the topics based on their objectives over the next 2-3 years. With that feedback, the TI team finalized a list of Research Priorities for approval by Agency executives.

Given the focus of TI, on technology development and demonstration, most detailed topics and statements of need are found in the Transmission Research Area. However, a new Research Area, *Products, Markets and Services*, emerged as TI discussed future needs with SMEs involved in BPA's analysis of potential new markets. Other stakeholders included SMEs and Managers involved in planning and operations, trading and scheduling functions of Power and Transmission as well as those planning and managing operations and cost associated with assets and infrastructure.

TI will make minor updates to Research Priorities each year based on the results of current projects, and developments in both business lines and industry. Once BPA has a new Strategic Plan beyond 2023, TI will undertake a more formal round of interviews and industry assessment to produce a new list of Research Priorities.

This product represents only those topics deemed high priority to BPA's business lines. It is the product of a comprehensive process of engagement with our internal BPA customers – Power, Transmission, and Information Technology to capture their research requirements for the next 3 years.

To learn more about TI's Research Agenda and process, visit TI's internal web site, Technology Innovation - DT - Home (bpa.gov).

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Section 1: New Approach to Research Priorities

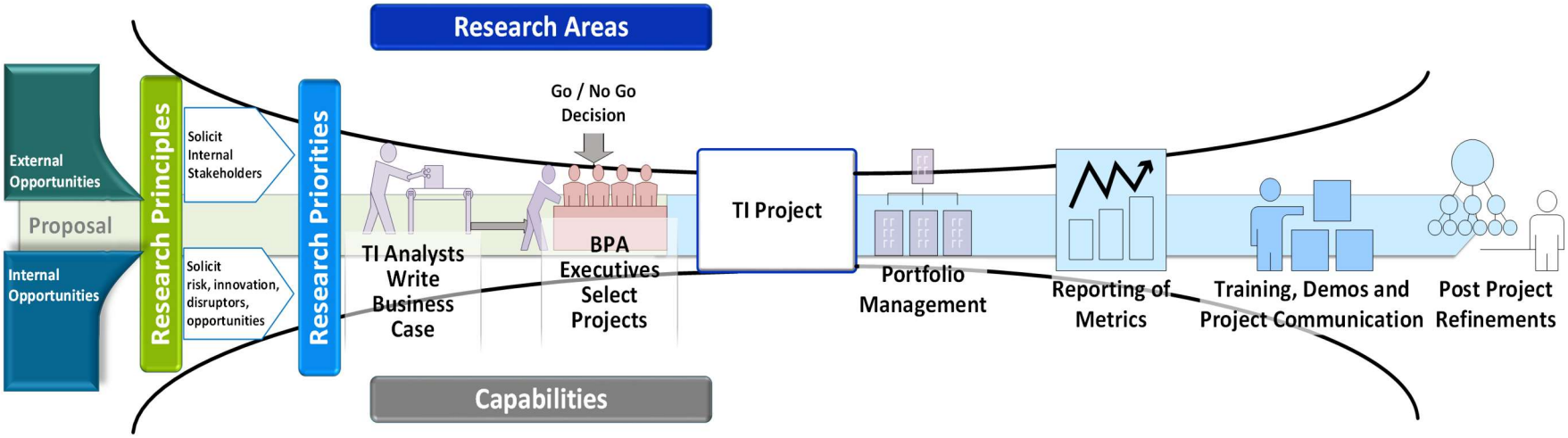
Research Priorities in the Research Agenda:

To create nimble processes for proposal development, value analysis and project selection, TI has codified a ***Research Agenda*** made of 4 elements: ***Research Areas, Research Principles, Capabilities, and Research Priorities.*** These 4 elements work together to categorize Research Priorities and to expand the value of RD&D projects developed by TI.

Research Areas	Research Principles	Capabilities	Research Priorities
Categories of research projects that are closely aligned to BPA business units and thus to BPA Mission Objectives. BPA Mission Objectives used by TI are those determined by federal statute. Research Priorities are listed by Research Area.	Standards used to determine the initial feasibility of proposals. These are static and based on Strategic Objectives and input from Agency leadership. Any proposal that does not meet TI's Research Principles is unlikely to warrant further consideration as a possible research project.	A category of work that cuts across business lines and is universally applicable no matter the scale. Capabilities may be associated with disciplines that serve to provide a foundation for best practice. Capabilities are made up of work that ranges from activities done by individual contributors to business units.	A list of research topics developed with input across the Agency that serve to define the type of RD&D necessary to support Agency and business line strategic objectives over a specific time period. This list is dynamic and represents the key risks and opportunities expressed by management and internal industry experts at a specific point for 2-3 years in the future.

TI's Process: Research Priorities within the Proposal to Project Funnel

As this diagram illustrates, Research Priorities make up a second "filter" for assessment of feasibility, scope and alignment with Strategic Objectives. Once proposals are deemed of significance to BPA, TI Analysts work to identify added value for cross-Agency capabilities and stakeholders. Finally, the proposals are reviewed and approved by Executives before project development and implementation.



Research Principles:

- Establish clear alignment to Agency or Business Line strategic objectives
- Clear sponsorship within the Agency
- Maximize Value-to-Cost ratio by seeking partnerships and collaborations where appropriate
- Clear path to implementation or value delivery
- Avoid primary research unless driven by business need

Research Priorities – Their purpose and use by Technology Innovation

Research priorities identify gaps in knowledge, practices or technology (including equipment and software) that, if reduced or closed, enable better planning, decision-making or processes that deliver savings in cost, complexity or time; or drive increased revenue. Focused on the next 2-3 years, Research Priorities are grouped by Research Area and are comprised of Topics, Research Priorities and specific needs or interests for each Topic. The TI team expects to do a formal review of Priorities annually by validating with SMEs and managers as well as Enterprise Risk and their work on the Industry Landscape, as well as scanning external industry research partners and entities.

The list of Research Priorities provides a tool for the TI team to seek out project opportunities with RD&D partners external to BPA and as a quick reference tool for inquiries. The general format for documenting Research Priorities is shown below.

Research Area	And associated organizations			**Capabilities** **Cross-Agency functions that expand value of RD&D Projects**			
Research Priorities	Expressed as Topics, Priorities and statements of interest or need						
	Topics	**Research Priorities**	**Statement of interest or need**				

BPA Functions represented in Agency Research Priorities

As a federal agency, the Bonneville Power Administration's statutory mission is to sell and deliver energy generated by dams owned and operated by the US Corps of Engineers and the US Bureau of Reclamation across the Pacific Northwest states of Oregon, Washington, northern Idaho and western Montana. To fulfill this mission, BPA created two business lines, Power Services and Transmission Services. The Power business line is mandated to serve public and investor owned utilities within these states before selling any surplus power to entities beyond the region. The Transmission business line transmits "federal power" to regional customers of BPA and transmits power for non-federal generators in the region who sell power throughout the west.

Pursuant to BPA's enabling statutes and in accordance with its mission, **Power Services** serves the Northwest by providing cost-based, reliable, low carbon products and services. With considerable customer input and public involvement, Power Services manages the generation and marketing of BPA's power products and services through its Business Operations, Energy Efficiency (PE), Generation Asset Management (PG), Requirements Marketing (PS), and Bulk Marketing (PT) organizations.

Transmission Services provides reliable open access, non-discriminatory transmission service on the BPA transmission network for utilities, generators, and power marketers consistent with various regulatory requirements. Transmission Services markets and sells transmission products and services, both regulated and unregulated, and provides asset management services for the transmission assets of the FCRPS through its Engineering & Technical Services (TE), Field Services (TF), System Operations (TO), Planning & Asset Management (TP), Marketing & Sales and Transmission Technology (TT) organizations.

	Research Areas association with the Value Chain			
	Markets, Products & Services	**Demand Response** **Hydro Assets** **Transmission**	**Hydro Generation & Models** **Demand Response** **Energy Efficiency** **Transmission**	**Energy Efficiency** **Transmission**
	Value Chain across BPA's Business Lines			
Power Services Value Chain	**Sell Power products and services**	**Manage Generation Assets**	**Plan Power Generation and Conservation**	**Service Power Customers**
	Northwest Requirements Marketing, PS **Bulk Marketing, PT**	**PG: Generation Asset Management** **Generating Assets, PGA:**	**PG: Generation Asset Management** **Energy Efficiency, PE:** **Engineering PEJD** **Distributed Energy Resources, PES**	Northwest Requirements Marketing, PS **Energy Efficiency, PE:** **Engineering PEJD** **Distributed Energy Resources, PES**
Transmission Value Chain	**Sell Transmission products and services**	**Manage Transmission Assets**	**Plan Transmission Operations and Delivery**	**Service Transmission infrastructure and Customers**
	Transmission Marketing and Sales, TS	**Planning and Asset Management, TP**	**System Operations, TO** **Engineering & Technical Services, TE**	**Engineering & Technical Services, TE** **Field Services, TF**
	IT, Communications and Cyber Security Research Area			
	Information Technology, IT or "J" and "TT" provide all development, installation and O&M of operational technology and information systems within the Value Chain. All Cyber Security functions reside within the IT function and provide the same cross functional standards and activities.			
	Legend	**Bold Black**: Contributed to Research Priorities Grey: Out of scope of RD&D Research but included for context in the value chain	**Blue Background**: Research Area Dark Blue Background: Value Chain Phase	

Section 2: Research Priorities by Research Area:

#1 STRENGTHEN FINANCIAL HEALTH #2 MODERNIZE ASSETS & SYSTEM OPERATIONS

Research Area: Hydro Assets

Functional Organizations: PGA

Topics	Research Priorities	Statement of interest / need
Hydropower equipment environmental risk reduction *Hydropower equipment presents hazards to the environment such as oil spills or fish injury. Many existing turbines were not designed for fish passage and various components contain hazardous chemicals. Specific research priorities should focus on new design that improve fish passage, improved lubricants or methods that reduce the impact to fish and the environment and continue to provide reliable power to reduce the risk of unplanned outage.*	**Fish Screen Impacts** *Fish screens are apparatis that serve to prevent fish from entering a power turbine or generating unit.*	• Can fish screens be removed while still meeting fish survival targets? • What testing or study information is needed to determine the impacts of removing fish screens? • Are different or new testing techniques needed to quickly understand the impact of operating with or without fish screens?
	Environmentally acceptable lubricants (EALs) *Improve the understanding of safety and suitability of environmentally acceptablt lubricants for dam and hydropower equipment. Encironmentally acceptable greases are also included.*	• Could new environmentally acceptable lubricants be developed for the dam and hydropower industry, which specifically address the challenges of that application? • Of the existing EALs, how would they affect the performance and longevity of dam and hydropower equipment? • Could laboratory, accelerated life, or field testing provide confidence in the long term suitability of EALs in dam and hydro equipment? • Could ester oils be safely utilized to retro-fill transformers and under what conditions would that be acceptable? • Would ester oil retro-fills affect the transformer expected life or performance?
	Modeling, testing, and monitoring turbine fish passage performance *The effect of turbine conditions on fish. Tools to model and predict passage performance of hydro equipment, especially turbines. Develop technology to more easily and cost effectively test fish passage, including tools for long-term monitoring to assess effects of egress conditions.*	• Is there more that we should understand about the effects of turbine conditions on fish, or are there key species and stressors that are not yet tested? • Could CFD models be developed further to model fish passage through turbines, including particle trajectories and fish behavior models? • Could CFD models be employed to predict or index fish survival through turbines, including calibration/validation to field scale data? • How could physical modeling techniques be improved to expedite data collection and analysis? • How could the cost and long term viability of tagging, tracking/monitoring systems be improved? • Could sensor fish be developed and applied to provide cost effective and accurate estimation of fish survival in field scale or model scale turbines?

	Oil-free Kaplan turbine technology development and confirmation *Further reduce risk to the environment by developing oil-free Kaplan turbine technology. Improve industry knowledge of optimal corrosion resistant materials and bushing materials to accommodate the trunnion loads and minimize wear. Vet materials and design parameters through lab testing and long term monitoring.*	• What are the fundamental challenges with oil-free Kaplan designs that diverge from conventional oil-filled Kaplan designs? • Are there industry standards for oil-less hub, linkage, and bushing materials? • Do self-lubricating or water lubricated bushing materials perform adequately under Kaplan trunnion loads? • How do wear rates of conventional Kaplan components compare to those of oil-less Kaplans? • How does corrosion affect wear rates and expected life of oil-free Kaplans? • Could operational and physical condition history of existing oil-free Kaplans be data mined to determine superior materials and design parameters, to estimate degradation/wear rates, and to predict expected life? • Are there tools available, or could they be developed, to easily model trunnion loads, cycles, bushing wear, and predict expected life?
Hydropower Reliability and Life Extension *Managed by Power's Generation Asset Management (PG) organization, this category of asset management focuses on maintaining reliability while extending the life of current generation assest through monitoring, enhancements; reduction or elimination of damage during normal operations.*	**Advanced online machine condition monitoring and condition assessment** *In general, these priorities focus on real-time monitoring of individual generating units. Specifically for 2020, the focus is on cavitation severity and noise.*	• Can online equipment monitoring tools be developed to facilitate a move to condition-based maintenance from time-based maintenance? • For cavitation monitoring: Is the cavitation occurring in the free stream or contacting metal surfaces? What is the location: leading edge, channel vortices, cone torch? How "intense" is the cavitation and is it damaging? How well do previously model tested cavitation ranges match actual observed ranges in the prototype scale? Could operating ranges be expanded or contracted? • Can noise (audio sensors) be used to predict degradation of components and/or need for maintenance? • Can new or existing online monitoring equipment be used for all or part of WECC system modeling requirements? • Can an online oil analysis system be developed and applied to measure degradation of equipment? • Can an online tool, using non-destructive methods, be used to monitor penstocks and gates? • Can measurement of residual stress determine fatigue life? Is there a way to quickly find cracks on blades when they are un-watered?

	New techniques for cavitation damage repair *Cavitation is caused by differences in static pressure of liquid. As water exists a turbine air bubble generate pressure wave of varied frequencies which lowers efficiency of of the turbine and thus power generation and may damage machinery over time.*	• Can the repair be done safely without disassembly of the unit? • What are the costs/economics of new approaches vs. traditional weld overlay and grind? • Can different materials such as stellite be used?

Research Area: IT, Communications and Cyber Security — Functional Organizations: J, TE, TT

Stakeholder inputs for information technology across BPA mention "self-healing" systems. Though this capability is vital to efficient and reliable real-time operations, standards are necessary to ensure the security of any technology and thus of the entire power generation and transmission system. To meet BPA's Information Technology and Cyber requirements, any technology must have the ability to capture security events and disseminate data about the events to a security information management system. Having a self-healing system is always a goal in the electric utility industry, however any such system that is not capable of recording and reporting security events is simply increasing the attack surface and is an obvious target.

BPA's Cyber Security Program maintains standards in a manual for ***Event Log Generation***. All BPA systems must log events based on this standard and will log the following where applicable and technically feasible. All research and development efforts to should seek to meet these requirements:

1. ***Event Log Generation***: Per BPA's Cyber Security Program standards for Event Log Generation. All BPA systems must log events based on this standard and will log the following:
   - Application startup
   - Application shutdown
   - Application failures
   - Major application configuration changes
   - Known failure states of any kind
   - Network communications with other hosts.
   - Privilege Use
   - Object Access
   - Directory service access
2. ***Authentication Log Generation***- All BPA systems will log events based on the guidance in this standards manual. All systems will have the following logged:
   - All authentication attempts
   - All authentication failures
   - All authentication success
   - Success or failure reading the audit record
   - Success and failure of binding security attributes to a user
   - Logon times
   - Log off times
   - Source IP address
   - MAC address
   - User name
   - Type of access (administrative, user, system, etc.)
   - Computer name of host where access was initiated
   - User account events
   - Creation of accounts
   - Modification of accounts
   - Disabling of accounts
   - Termination of accounts

Topics	Research Priorities	Statement of interest / need
Operational Technology *Automated systems used to monitor and manage generation and delivery of power.*	**Threat detection** *Real-time detection of attempts to penetrate automated systems or software applications.*	• How can we detect anomalies that could indicate invasive attempts to breach operating systems or technology (OT)? • How can we identify normal issues with data streams to omit these for better threat detection? • Cyber prototyping with national laboratories on monitoring of automated electric utility substation and control center technology that can be centralized and fed to a security event information management system.

Research Area: Transmission

Functional Organizations: TE, TF, TO, TP

Topics	Research Priorities	Statement of interest / need
Wildfire	**Situational awareness across BPA's operating region** *Real-time awareness of the conditions under which wildfire may start; or conditions that requiring immediate response to prevent fire start or ensure the safety of fire responders.*	• Early detection of fire • Weather conditions – alert system by locality • Assets at greatest risk of wildfire, geographic awareness, • Outage management, pre-emptive outages to prevent fires • Vegetation management, UAV for vegetation assessment • Sensor deployment and wireless connectivity to provide rapid communication • Visibility to all conditions across wide geographic area
High impact events *A high impact event is described as impacting a larger area, for a longer duration. Infrequent or not routine, these include pandemic, EMP, subduction zone earthquake, coordinated cyber attack.*	**Artificial intelligence** *The development and use of computer systems able to perform tasks that normally require human intelligence and decision making. Includes "machine learning" of repeated trends or events.*	• How may AI support advanced warning of high impact events within generation or distribution systems.? • What sort of alert system might be developed to advise human monitors of the need to react to sustain reliability or minimize damage to generation or transmission infrastructure?
High Impact Events - Seismic *A high impact event is described as impacting a larger area, for a longer duration. Infrequent or not routine, these include pandemic, EMP, subduction zone earthquake, coordinate cyber attack.*	**Tower fragility given tower/conductor configurations** *Analysis of critical seismic parameters to determine effects on the performance of transmission line tower/conductor configurations and development of transmission line tower seismic fragility function*	What are the critical ground motion parameters that affect the seismic performance of a transmission line (towers/conductors) system? • What are the critical transmission line configurations for seismic performance evaluation analysis? • What is the difference in seismic performance between standard towers vs. major river crossing towers? • What is the difference in structural seismic performance using tubular poles, lattice towers, and wood pole structures? • Can transmission tower seismic fragility functions be developed to assist utilities performing risk assessments? • How does seismic response results compare with the traditional detecton systems?

	Tower placement guidelines *Guidelines for placement of transmission towners in vulnerable sites with earthquake generated landslides, liquefaction, lateral spreading and rock fall hazards.*	• What mitigation options are available for addressing legacy installation to earthquake generated landslides, liquefaction, lateral spreading, and rock falls? • Can applicable engineering guidelines be provided for installation of transmission lines and towers in special locations with the potential for earthquake generated landslides, liquefaction, lateral spreading, and rock falls? • Can engineering limits be provided to improve the transmission tower seismic thresholds?
High Impact Events – Geomagnetic *A high impact event is described as impacting a larger area, for a longer duration. Infrequent or not routine, these include pandemic, EMP, subduction zone earthquake, coordinate cyber attack.*	**Geomagnetic Disruption** *Disruption caused by solar storm; a shock wave and/or magnetic cloud emitted by the sun that interacts with Earth's magnetic field. Such magnetic waves can cause distruption of electric transmission and communications*	• GMD - Geomagnetic Disturbances and GIC - Geomagnetic Induced Currents: Application of automation to detect and respond to reduce or avoid damage by shutting down equipment
Risk-Based Planning / Probablistic Planning *Risk-based planning is the application of risk or opportunity assessment to understand impacts then select mitigations that ensure the achievement of objectives.* *When combined with probabilistic planning, decision making may be made with greater certainty of risk impacts and possible outcomes.* **Probablistic Planning:** *Deciding on objectives or selecting options based on forecasts of events. Such forecasts are created from historic known evidence and a set of probabilities associated with all possible future outcomes.*	**Probablistic transmission planning** *Creation of plans for O&M of transmission infrastructure based on forecasting of events based on historic known evidence and a set of probabilities associated with all possible future outcomes.*	• How can we achieve better integration of data within RT studies in the overall flow from outage planning and week ahead (Ops planning) through current day ahead and RT? • How can we use automation to identify issues in hours ahead to avoid RT surprises and constraints?

	Real-time modeling: *Modeling and forecasting in real time based on probabilistic models. Such modeling may provide more in-depth information or specific options that operators may wish to exercise for optimal real-time operations with least risk/cost and greatest effectiveness or profit.*	Provide a more cohesive picture of reliability risks in RT and near term, with a wider toolset • Incorporate RCA and RT stability, how can we bring all the results together in one system? • What data and information along with such tools can provide a good understanding of the RT state of the system and the state of the system in the forecast window so that we may have more lead time to respond and adjust?

Appendices:

Appendix 1: Research Area Definitions

Please note: ***Grey text indicates Research Areas where high priority topics were not identified for FY21 and FY22.***

Demand Response: Demand response is a change in the power consumption of a BPA customer to better match the demand for power. At BPA this means we have agreements with external entities to decrease consumption of energy to lower the demand during peak periods when our system cannot generate enough power and/or buying power to augment BPA's generation is costlier than calling upon these pre-established agreements. RD&D projects have historically focused on specific technology, proof of concept or DR capabilities.
Energy Efficiency: Due to projected energy gaps, the federal government has required energy conservation (a.k.a. energy efficiency) of all PMU's. BPA established a robust organization with rigorous methods to identify, develop and implement conservation measures across the BA. This category captures all research necessary to understand the feasibility of conservation methods, the true energy savings and which may be most significant to BPA.
Hydro Assets: Though BPA owns no generating resources, the Agency is responsible to aid in planning and bear the full cost for O&M of all federal power plans and their associated turbines. For this reason, any technology, tools, improvements related to hydro turbines or their components is of great interest to BPA. This category captures any work done to understand where savings in cost, reduction in risk or new technology may be of interest to BPA.
Hydro Generation / Models: A major component of BPA's hydro operations is forecasting load (demand for energy) and generation. This category is intended to represent any work to investigate new or improved methodology that is useful to these key functions.
IT, Communications and Cyber Security: This category is largely the technological (hardware and software) solutions put in place across the Agency to manage systems in a secure manner; to provide secure and efficient communications. Cyber Security was added in FY20 due to the significant risk posed by possible attacks and the federal mandates for specific cyber security activities.
Markets, Products & Services: New to TI in FY20, this category represents any investigation of technology (hardware or software) that may be used to better understand where and how BPA may develop an understanding of trends or pricing and to understand gaps so they may develop new offerings that deliver products or services to others for reliability or resilience services and thus, contribute to revenues. TI anticipates that any RD&D work in this area will be limited to investigation of artificial intelligence, data analysis methods or automated process of existing data for new insights.
Transmission: Traditionally anything related to work done in Transmission planning, engineering related to power flow and infrastructure and work done by "field" personnel who set up and maintain the physical elements of the transmission system. Includes all categories of transmission assets.

Appendix 2: Alignment to Mission Objectives

Research Areas and Priorities matrixed to Strategy and Mission Objectives

Research Areas have been used by TI to categorize projects that support specific business functions within the Agency; these also demonstrate alignment with BPA's Mission Objectives. Like Research Principles, these are static and seldom change given the strong association with the Agency Mission.

		Mission Objectives			Business Line	
		Sale and management of energy	Sale and Management of Transmission	Safety, Industry and Regulatory Compliance	Power	Transmission
Research Area	**Research Priority Topics**	X = major alignment, / = some alignment				
Hydro Assets #1 STRENGTHEN FINANCIAL HEALTH #2 MODERNIZE ASSETS & SYSTEM OPERATIONS	Hydropower equipment environmental risk reduction Hydropower Reliability and Life Extension	**X**		**X**	**PGA**	
IT, Communications and Cyber Security: #3 PROVIDE COMPETITIVE POWER PRODUCTS & SERVICES #2 MODERNIZE ASSETS & SYSTEM OPERATIONS #4 MEET TRANSMISSION CUSTOMER NEEDS EFFICIENTLY & RESPONSIVELY	Operational Technology: Threat Detection	**X**	**X**	**X**	**All**	**All**
Transmission #1 STRENGTHEN FINANCIAL HEALTH #2 MODERNIZE ASSETS & SYSTEM OPERATIONS #4 MEET TRANSMISSION CUSTOMER NEEDS EFFICIENTLY & RESPONSIVELY	Wildfire High impact events: Seismic, Geogmagnetic Risk-Based Planning / Probablistic Planning	**/**	**X**	**X**		**TE,TF, TO, TP**